# ANALYSIS OF DRIVING BEHAVIOR OF FREIGHT TRANSPORT DRIVERS ON THE TABANAN-GILIMANUK ROAD, BALI PROVINCE

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## ABSTRACT
Safety and security vehicle transport goods on the road is obligations that must be fulfilled fulfilled by every vehicle motorized. However, its implementation in Indonesia is still not optimal, it looks from height number accidents. In 2024, the Indonesian National Police recorded 116,000 cases accidents, increased by 6.8% compared to year previously. Some the cause covering system problem braking and human error factors due to behavior driving that is not safe. Methodology in research This that is analysis descriptive with analyze behavior driver on the aspect style braking, speed, force maneuver. The purpose of research This that is for know behavior drivers on the Tabanan Gilimanuk road with use braking smoothness tool. In the aspect speed from all driver be at speed safe This namely 8.36 m/s (around 30 km/h) to 10.99 m/s (around 39.6 km/h). In this aspect style braking from 24 samples driver obtained that 16 drivers or 67% get results style braking with category (soft braking) namely (-0.19 to -0.21 g force) while 8 drivers or 33% get style braking with category (harsh braking) namely - 0.22 g force. In this aspect style maneuver from 24 samples vehicle obtained that 14 drivers 58% got results style maneuver with category (low risk) namely (-0.14 to -0.2 g force) while 10 drivers or 42% get style maneuver with category (moderate risk), namely (-0.21 to -0.23 g force). Findings This show that majority drivers on the Tabanan –Gilimanuk route Still show behavior drive safely and carefully.

Keyword: braking; brassmooth tools; freight transport; maneuvering; speed

## INTRODUCTION
Vehicle motorized own role important in support growth economic, social and cultural Because functioning as means main mobility of people and goods interregional in a way effective and efficient. However, safety vehicle transport goods on the road Still become challenge is a major problem in Indonesia. Based on data from the Indonesian National Police in 2024, there were 116,000 recorded cases. accident Then cross, increased by 6.8% compared to year previously. Most of accident caused by problems with the system braking and human error factors due to behavior driving that is not safe. Braking sudden, maneuver sharp, and speed excessive become reason main increasing risk accidents, especially on the road with condition slippery. Besides being dangerous safety, behavior it also speeds up damage component vehicle as well as lowerlevel suitability road vehicles (Perepjolkina, 2018; Botzer et al., 2019).

Approaching end 2024, activities transportation land in Bali is experiencing improvement significant. Based on data from the Management Center Land Transportation (BPTD), recorded as much as 20,181 units vehicle crossing track Tabanan– Gilimanuk main with an average of 673 vehicles per day, which has the potential increase risk accident. As response, National Committee for Safety Transportation (KNKT) recommends various step prevention like evaluation management risk, increase suitability vehicles, as well as education and training for drivers and technician vehicles. This is also in line with results study previously shown that use tool like an effective tachometer for control behavior driver (Noviyanti, 2015), and that perception risk own influence significant to safety driving (Darmawan, 2019).
Study This focus on analysis behavior driving driver transport goods on Tabanan –Gilimanuk Road use Braking Smoothness tool designed for measure aspect speed, force braking, and style

maneuver moment bend. Formula problem in study This includes two things main, namely results reading Braking Smoothness tool based on speed and force parameters braking , and style maneuvering on corners, as well as behavior driving driver transport goods on track The research objective This is obtain quantitative data from results measurement tools and identify characteristics behavior driving driver truck goods on track with condition uphill and downhill. Research restricted to vehicles transport goods with configuration axis 1.2 and load load 7,500 kg, with location observations on the Tabanan– Gilimanuk Road in the range 06.00–18.00 WITA. Aspects measured covering activity braking, speed, and force maneuver moment through bend. Research This expected give contribution to development behavioral monitoring instruments capable driving generate quantitative data more accurate compared to classification qualitative such as “soft”, “medium”, or “coarse”, as well as become step innovative in utilization of science and technology in the Transportation Human Resources Development Agency (BPSDMP) environment for increase safety driving and efficiency transportation.

## METHODS

Study This is experiment quantitative purposeful analyze influence increase burden car goods to primary braking capability through stages studies libraries, experiments, data processing and analysis, and withdrawal conclusion (Darmadi, 2013).

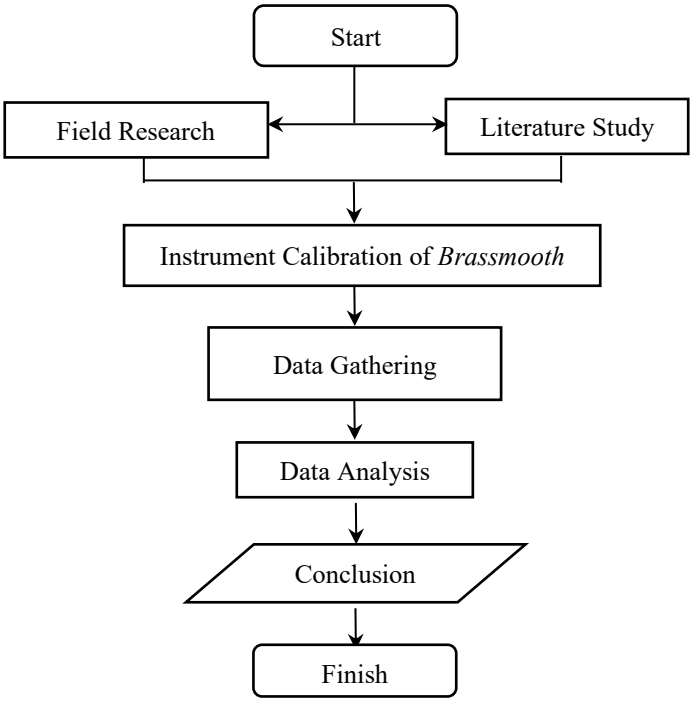



Figure 1. Flowchart study

### Literature Study and Field Study

The first phase of this research included a literature review and fieldwork. The literature review was conducted by reviewing relevant books, journals, and previous research, both printed and digital. Meanwhile, the field study involved testing a prototype vehicle smoothness tester on a freight vehicle to obtain quantitative data on braking, maneuvering force, and vehicle speed.

### Calibration Process

Prototype testing was conducted on the Poltrada Bali Tabanan braking training track at an ideal speed of 30–40 km/h and a braking time of approximately 5 seconds. The purpose of this test was to obtain prototype performance data including speed, acceleration, braking force (g-force),

and deceleration. All test data is automatically recorded in a data logger and can be extracted via a micro-SD card for further analysis.

**Research Sample**

According to Sugiyono (2015), a sample is a portion of a population that shares certain characteristics. In this study, the sample used was 24 freight transport drivers with a 1.2 axle configuration on the Tabanan–Gilimanuk route. This number was obtained from the results of a three-day traffic counting survey at three peak times: morning (6:00–8:00), afternoon (11:00–1:00), and evening (4:00–6:00 PM), with an average of 24 vehicles passing each day.

Data collection was carried out at 06.00–18.00 WITA with stages as following: determination point departure at Tabanan Preparation Terminal, negotiation with driver, installation tool brassmooth which has calibrated on the vehicle dashboard, as well asmentoring vehicle going to Weighbridge and route on the contrary heading to Tabanan for additional data collection.

Table 1.
*Traffic counting* results for the Tabanan-Gilimanuk road section

| Time | Transport (Configuration 1.2) | | |
|---|---|---|---|
| | Day 1 | Day 2 | Day 3 |
| 06.00-06.15 | 2 | 0 | 1 |
| 06.15-06.30 | 2 | 1 | 0 |
| 06.30-06.45 | 1 | 1 | 2 |
| 06.45-07.00 | 2 | 1 | 1 |
| 07.00-07.15 | 2 | 1 | 0 |
| 07.15-07.30 | 0 | 0 | 1 |
| 07.30-07.45 | 0 | 2 | 2 |
| 07.45-08.00 | 1 | 1 | 2 |
| 11.00-11.15 | 0 | 1 | 0 |
| 11.15-11.30 | 0 | 0 | 1 |
| 11.30-11.45 | 0 | 1 | 2 |
| 11.45-12.00 | 1 | 0 | 2 |
| 12.00-12.15 | 0 | 0 | 0 |
| 12.15-12.30 | 2 | 2 | 0 |
| 12.30-12.45 | 2 | 2 | 2 |
| 12.45-13.00 | 0 | 0 | 2 |
| 16.00-16.15 | 2 | 2 | 1 |
| 16.15-16.30 | 2 | 2 | 2 |
| 16.30-16.45 | 0 | 2 | 2 |
| 16.45-17.00 | 0 | 0 | 0 |
| 17.00-17.15 | 2 | 2 | 0 |
| 17.15-17.30 | 2 | 1 | 0 |
| 17.30-17.45 | 1 | 0 | 2 |
| 17.45-18.00 | 0 | 0 | 0 |
| Total | 24 | 22 | 25 |
| Average | | 23.6 | |

Figure 2. Documentation survey introduction

**Data analysis**

Analysis of data used in the research This is analysis descriptive with analyze behavior driver on the aspect style braking, speed, force maneuver. Data analysis used in the research This is analysis descriptive with analyze behavior driver on the aspect style braking, speed, force maneuver.

## RESULT AND DISCUSSION

### Calibration Process

Calibration done for ensure tool brassmouth functioning with accurate. Testing done on the track standard with measure speed beginning, time braking, and style braking (g-force). The g-force value of tool compared to with results manual calculations using GLBB formula to find out deviation. Experiment done as many as 16 times with procedure: vehicle spurred on until speed of 30 km/hour, then done braking in a 20 m long test zone. The results show tool brassmouth own level 91% accuracy, indicating deviation small and performance excellent tool. With Thus, the tool This assessed worthy used for testing field Because capable give results precise and consistent measurements.

Table 2.
Results of data collection and calculation of experimental data for tool calibration

| No | Vt (km/h) | Vt (m/s) | t (s) | s (m) | a (m/s^2) | *G-Force* Braking Tool | *G-Force* Calculation Braking | *G-Force* Rolling | *G-Force* Pitching | Output System | | | | | % Deviation Measurement | % Accuracy Measurement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Audio ( *Buzzer* ) | Visual ( *Display* and LED) | *Data Logger* | | | | |
| | | | | | | | | | | | | Braking *G-Force* | *G-Force* Rolling | *G-Force* Pitching | | |
| 1 | 30.21 | 8.39 | 4.8 | 20 | -1.77 | 0.19 | 0.18 | 0.092 | 0.057 | No Sound | *Soft Braking, LED off* | 0.19 | 0.092 | 0.057 | 6% | 94% |
| 2 | 30.45 | 8.46 | 4.9 | 20 | -1.71 | 0.19 | 0.17 | 0.092 | 0.057 | No Sound | *Soft Braking, LED off* | 0.19 | 0.092 | 0.057 | 12% | 88% |
| 3 | 29.59 | 8.22 | 5.1 | 20 | -1.6 | 0.18 | 0.16 | 0.088 | 0.054 | No Sound | *Soft Braking, LED off* | 0.18 | 0.088 | 0.054 | 13% | 88% |
| 4 | 29.2 | 8.11 | 5.5 | 20 | -1.47 | 0.17 | 0.15 | 0.083 | 0.051 | No Sound | *Soft Braking, LED off* | 0.17 | 0.083 | 0.051 | 13% | 87% |
| 5 | 29.97 | 8.33 | 4.7 | 20 | -1.79 | 0.2 | 0.18 | 0.097 | 0.06 | No Sound | *Soft Braking, LED off* | 0.2 | 0.097 | 0.06 | 11% | 89% |
| 6 | 29.35 | 8.15 | 2.6 | 20 | -3.15 | 0.33 | 0.32 | 0.16 | 0.099 | Sounds | *Hard Braking, LED on* | 0.33 | 0.16 | 0.099 | 3% | 97% |
| 7 | 30.26 | 8.41 | 5.3 | 20 | -1.58 | 0.18 | 0.16 | 0.088 | 0.054 | No Sound | *Soft Braking, LED off* | 0.2 | 0.088 | 0.054 | 13% | 88% |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 29.82 | 8.28 | 5 | 20 | -1.64 | 0.19 | 0.17 | 0.092 | 0.057 | No Sound | *Soft Braking, LED off* | 0.19 | 0.092 | 0.057 | 12% | 88% |
| 9 | 29.82 | 8.28 | 5.6 | 20 | -1.48 | 0.16 | 0.15 | 0.078 | 0.048 | No Sound | *Soft Braking, LED off* | 0.18 | 0.078 | 0.048 | 7% | 93% |
| 10 | 29.12 | 8.09 | 4.8 | 20 | -1.69 | 0.21 | 0.17 | 0.102 | 0.063 | No Sound | *Soft Braking, LED off* | 0.21 | 0.102 | 0.063 | 24% | 76% |
| 11 | 29.68 | 8.24 | 5.6 | 20 | -1.46 | 0.17 | 0.15 | 0.083 | 0.051 | No Sound | *Soft Braking, LED off* | 0.21 | 0.083 | 0.051 | 13% | 87% |
| 12 | 29.22 | 0.12 | 5.2 | 20 | -1.56 | 0.16 | 0.16 | 0.078 | 0.048 | No Sound | *Soft Braking, LED off* | 0.16 | 0.078 | 0.048 | 0% | 100% |
| 13 | 29.38 | 8.16 | 4.9 | 20 | -1.66 | 0.18 | 0.17 | 0.088 | 0.054 | No Sound | *Soft Braking, LED off* | 0.19 | 0.088 | 0.054 | 6% | 94% |
| 14 | 29.22 | 8.12 | 5.6 | 20 | -1.46 | 0.16 | 0.15 | 0.078 | 0.048 | No Sound | *Soft Braking, LED off* | 0.2 | 0.078 | 0.048 | 7% | 93% |
| 15 | 29.78 | 8.27 | 5 | 20 | -1.65 | 0.19 | 0.17 | 0.092 | 0.057 | No Sound | *Soft Braking, LED off* | 0.19 | 0.092 | 0.057 | 12% | 88% |
| 16 | 31.48 | 8.74 | 2 | 20 | -4.37 | 0.46 | 0.45 | 0.224 | 0.1 | Ringing | *Hard Braking, LED on* | 0.46 | 0.224 | 0.1 | 2% | 98% |
| | | | | | | | | *Avg.* | | | | | | | 9.48% | 91% |

**Data Acquisition**

The traffic counting survey resulted in a sample of 24 freight transport drivers on the Tabanan-Gilimanuk route. Data collection was conducted between 6:00 and 18:00 WITA, departing from the Tabanan Pesiapan Terminal. Researchers installed a calibrated Brassmooth device on the dashboard of the sample vehicles after negotiating with the drivers. The team then followed the journey to the Weighbridge and performed the same procedure on the return trip to Tabanan. Driver behavior data was collected through direct observation to capture behavioral variations under different traffic conditions.

Figure 3. Data collection process

**Tool Reading Results**

After the calibration process the tools and data collection were carried out according to procedures, resulting in measurement results that describe driver behavior when braking. A total of 24 drivers participated in the trial using *the Braking Smoothness Tester*, a device designed to objectively measure the smoothness and effectiveness of braking. Each driver underwent the same test stages, from vehicle preparation, sensor installation, to braking at a specific point. During the test process, the device recorded parameters such as initial speed, braking intensity, deceleration duration, and braking rate. refinement braking.

Data obtained processed become Structured information was used to analyze variations in braking force between respondents. The analysis focused on three main aspects: driving habits, reaction speed to braking conditions, and compliance with driving safety standards. The results allowed researchers to distinguish drivers with smooth and measured braking techniques from

those who brake abruptly or erratically. A summary of the research results is presented in Table 4.2, which contains readings from the *Braking Smoothness Tester.* Significant variations between drivers were observed, reflecting differences in characteristics and braking behavior. as well as control vehicle.

Table 3.
Research results

| No | Date | Time | Name | Load Type | $\bar{X}$ Speed (m/s) | $\bar{X}$ Braking Force *(g-force)* | $\bar{X}$ Maneuvering Force *(g-force)* | Braking Style Classification | Classification of Maneuver Styles |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1/4/2025 | 08.00 – 10.30 | Wayan Sudarta | Fruits | 8.59 | -0.18 | -0.14 | *Soft Braking* | *Low risk* |
| 2 | 1/4/2025 | 14.00 – 16.30 | Made Suardika | LPG gas | 10.44 | -0.21 | -0.2 | *Harsh Braking* | *Low risk* |
| 3 | 3/4/2025 | 10.00 – 12.30 | Eko Prasetyo | Clothing and Textiles | 9.46 | -0.19 | -0.23 | *Soft Braking* | *Moderate risk* |
| No | Date | Time | Name | Load Type | $\bar{X}$ Speed (m/s) | $\bar{X}$ Braking Force *(g-force)* | $\bar{X}$ Maneuvering Force *(g-force)* | Braking Style Classification | Classification of Maneuver Styles |
| 4 | 3/4/2025 | 15.00 – 17.30 | Heri Setiawan | Electronic Equipment | 10.80 | -0.22 | -0.18 | *Harsh Braking* | *Low risk* |
| 5 | 5/4/2025 | 10.00 – 12.30 | Nyoman Sukadana | Sea food | 10.35 | -0.21 | -0.14 | *Harsh Braking* | *Low risk* |
| 6 | 5/4/2025 | 14.00 – 16.30 | Ketut Darmayasa | Cement | 10.88 | -0.22 | -0.22 | *Harsh Braking* | *Moderate risk* |
| 7 | 6/4/2025 | 08.00 – 10.30 | Adi Saputra | Bottle | 8.54 | -0.17 | -0.22 | *Soft Braking* | *Moderate risk* |
| 8 | 6/4/2025 | 14.00 – 16.30 | Budi Santoso | Cement | 9.93 | -0.20 | -0.19 | *Soft Braking* | *Low Risk* |
| 9 | 12/4/2025 | 08.00 – 10.30 | Yanto Purwanto | Sand and Stone | 8.93 | -0.18 | -0.19 | *Soft Braking* | *Low Risk* |
| 10 | 12/4/2025 | 14.00 – 16.30 | Samsul Arifin | Paddy and Rice | 10.02 | -0.20 | -0.14 | *Soft Braking* | *Low Risk* |
| 11 | 04/13/2025 | 10.00 – 12.30 | Udin Wahyudi | Fresh Vegetables and Fruits | 10.14 | -0.21 | -0.21 | *Soft Braking* | *Moderate risk* |
| 12 | 04/13/2025 | 15.00 – 17.30 | Fajar Nugroho | Light Industrial Goods | 9.57 | -0.20 | -0.21 | *Soft Braking* | *Moderate risk* |
| 13 | 04/19/2025 | 08.00 – 10.30 | Nyoman Adnyana | Plastic Goods and Plastic Processed Products | 10.38 | -0.21 | -0.18 | *Harsh Braking* | *Low Risk* |
| 14 | 04/19/2025 | 14.00 – 16.30 | Ketut Yasa | Parcel/E-commerce Logistics | 8.69 | -0.18 | -0.22 | *Soft Braking* | *Moderate risk* |
| 15 | 04/20/2025 | 08.00 – 10.30 | Made Wirawan | Bricks and Cement Blocks | 8.44 | -0.17 | -0.21 | *Soft Braking* | *Moderate risk* |
| 16 | 04/20/2025 | 14.00 – 16.30 | I Wayan Sukarta | Cement | 8.36 | -0.17 | -0.15 | *Soft Braking* | *Low Risk* |
| 17 | 04/26/2025 | 08.00 – 10.30 | I Made Ardana | Grains (Corn, Soybeans) | 8.39 | -0.17 | -0.21 | *Soft Braking* | *Moderate risk* |
| 18 | 04/26/2025 | 14.00 – 16.30 | I Nyoman Sudiarta | Sugar | 10.29 | -0.21 | -0.21 | *Soft Braking* | *Moderate risk* |
| 19 | 04/27/2025 | 10.00 – 12.30 | I Ketut Wirata | Reinforced Concrete / Light Steel | 9.76 | -0.20 | -0.14 | *Soft Braking* | *Low Risk* |
| 20 | 04/27/2025 | 15.00 – 17.30 | I Gede Suardana | Electronic Equipment | 9.29 | -0.19 | -0.21 | *Soft Braking* | *Moderate risk* |
| 21 | 3/5/2025 | 10.00 – 12.30 | I Komang Adiputra | Paddy and Rice | 10.98 | -0.22 | -0.19 | *Harsh Braking* | *Low Risk* |

| No | Date | Time | Name | Load Type | X̄ Speed (m/s) | X̄ Braking Force *(g-force)* | X̄ Maneuvering Force *(g-force)* | Braking Style Classification | Classification of Maneuver Styles |
|---|---|---|---|---|---|---|---|---|---|
| 22 | 3/5/2025 | 15.00 – 17.30 | I Putu Suryawan | Cooking Oil and Other Staples | 10.96 | -0.22 | -0.16 | *Harsh Braking* | *Low Risk* |
| 23 | 4/5/2025 | 10.00 – 12.30 | Gede Agus Saputra | Building Materials (Roof Tiles, Asbestos, etc.) | 10.99 | -0.22 | -0.18 | *Harsh Braking* | *Low Risk* |
| 24 | 4/5/2025 | 15.00 – 17.30 | Komang Rai Sudarsana | Paddy and Rice | 10.02 | -0.20 | -0.14 | *Soft Braking* | *Low Risk* |

**Measurement results Speed, Braking Force, and Driver Maneuvering Force**

Based on the instrument readings, the data showed significant variations in each driver's speed. Recorded speeds ranged from 8.36 m/s (±30 km/h) to 10.99 m/s (±39.6 km/h), as shown in Figure 4.

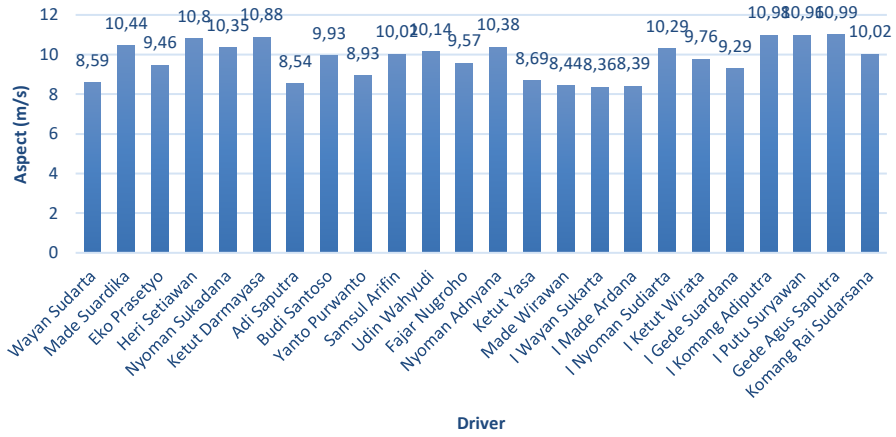



Figure 4. Speed aspect data for each driver

When compared with the provisions of PM No. 111 of 2015, this range is still within safe limits for freight vehicles on non-toll roads, which generally have a speed limit of 60–80 km/h. These results also align with research by Hidayat et al. (2021) which recorded a free-flow speed on the route of 46.48 km/h (12.9 m/s). Regarding braking force, the measurement results shown in Figure 5 show a variation in *g-force values* between -0.17g and -0.22g.

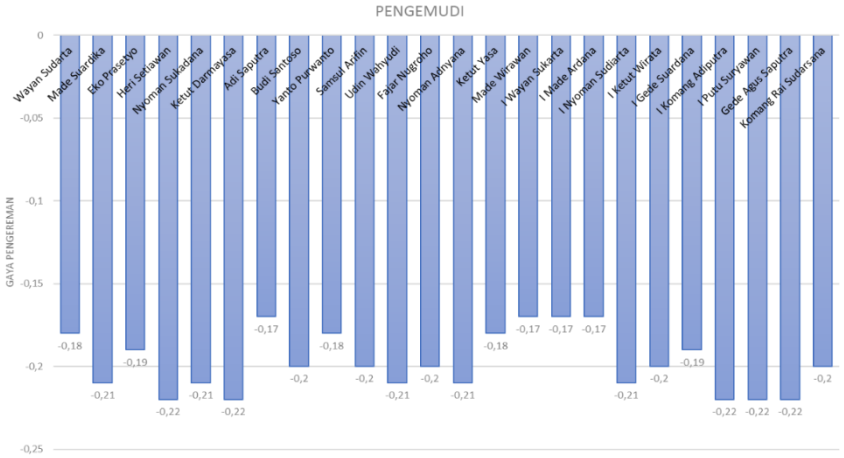



Figure 5. Braking force aspect data for each driver

Based on the range, it is included in the *soft braking* (-0.09 to -0.2 g) and *harsh braking* (-0.2 to -0.4 g) categories. A total of 16 drivers (67%) showed a soft braking force. Meanwhile, 8 drivers (33%) showed hard braking . These values are also visualized in Figure 6, which illustrates the variation in braking levels between drivers. Meanwhile, in the maneuvering force aspect shown in Figure 6, the *g-force values* recorded ranged from -0.14 g to -0.23 g.

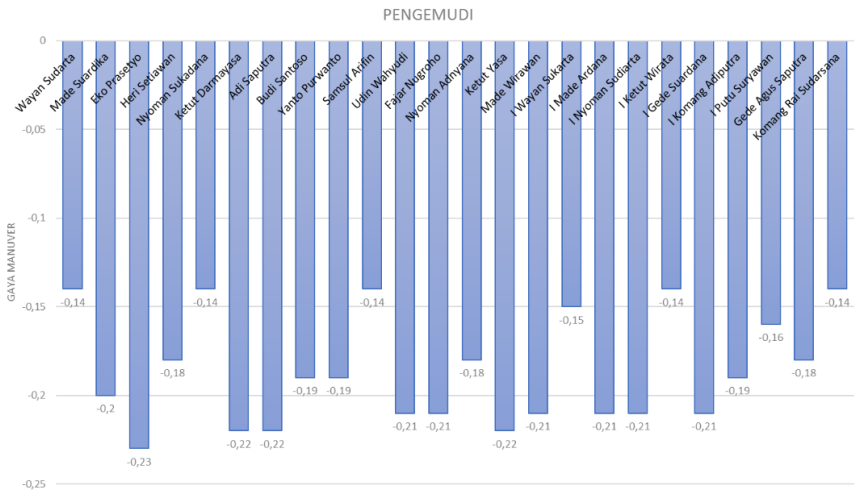



Figure 6. Data on maneuvering style aspects of each driver

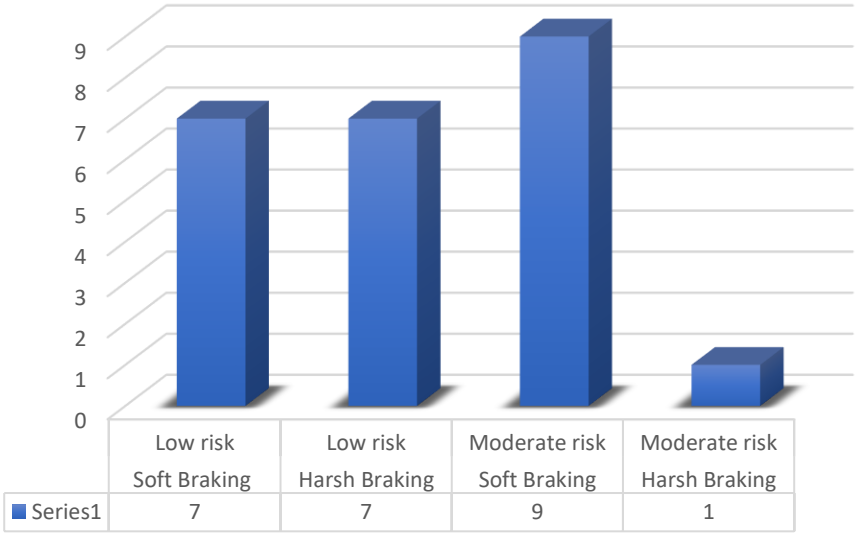
These values are categorized as *low risk* (-0.13 to -0.2 g) and *moderate risk* (-0.21 to -0.25 g). Of the 24 drivers, 14 (58%) demonstrated a safe maneuvering style ( *low risk* ), while 10 (42%) were in the moderate risk category . The graph of vehicle maneuvering style results above illustrates the distribution of maneuvering stability levels for each driver. Overall, these results indicate that most freight transport drivers on the Tabanan-Gilimanuk route are still within safe limits in terms of speed, braking, and maneuvering. However, the presence of some drivers with high *g-force values* indicates the need for increased awareness in braking and maneuvering techniques to ensure driving safety.

**Behavior Driving Driver**

After the analysis, braking force and maneuvering force were categorized to identify driving behavior on the Tabanan–Gilimanuk Road as shown in Table 4. From the 24 vehicle samples tested, the results showed variations in behavior that reflected traffic conditions and characteristics of winding, uphill, and goods vehicle-congested routes.

Table 4.
Braking style and maneuvering style categories

| Braking Style | Maneuvering Style | Description |
|---|---|---|
| *Soft Braking* | *Low Risk* | Gentle braking with a smooth and gradual reduction in speed. |
| *Harsh Braking* | *Low Risk* | Hard braking is done with good control, safely and under control. |
| *Soft Braking* | *Moderate Risk* | Soft braking can potentially cause loss of control on slippery roads or in bad weather. |
| *Harsh Braking* | *Moderate Risk* | Hard braking can risk skidding or causing damage if not done carefully. |




Based on the distribution results, there were 7 drivers with *soft braking* and low risk , 7 drivers with *harsh braking* but still *low risk* , 9 drivers with *soft braking* at *moderate risk* , and 1 driver with *harsh braking* at *moderate risk* . In general, the majority of drivers exhibited low-risk driving behavior, although the braking techniques used varied. This finding confirms that other factors such as speed, road conditions, and response to traffic situations also influence the level of risk. These results are expected to support the improvement of driving safety and form the basis for the development of more effective educational strategies and driver behavior interventions.

## CONCLUSION

The results of the study indicate that the braking behavior of freight transport drivers is influenced by speed, braking force, and maneuvering style on corners. Vehicle speeds recorded between 8.36 m/s (±30 km/h) to 10.99 m/s (±39.6 km/h) and are still considered safe. However, at high speeds, braking patterns tend to be sudden, thus reducing the *braking smoothness value* . The measured braking force ranged from -0.17g to -0.22g, indicating that the majority of drivers were in the *soft braking* and *harsh braking categories*. Braking too hard risks reducing stability, especially in heavily loaded vehicles. Meanwhile, maneuvering force ranged from -0.14g to -0.23g, which is generally in the *low risk* and *moderate risk categories*, indicating that drivers are able to maintain vehicle stability on corners with smooth braking. Overall, the majority of freight drivers on the Tabanan–Gilimanuk route demonstrate safe and careful driving behavior. However, a small number of drivers engage in harsh braking and moderate-risk maneuvers, which require attention to improve traffic safety on this route.

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